FERMENTABLE FIBER FOR YEAR-ROUND EWE MILK PRODUCTION

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INTRODUCTION

Seasonal production is a major constraint for ewe milk production in the US and Europe (Sitzia et al., 2015). Typical US dairy breeds (East Friesian and Lacaune) are seasonal polyestrous with low conception rates in off-season months, achieving one annual 160- to 180-day lactation. As a result, the US sheep dairy industry consists of a humble number of mainly small-scale family farms producing artisanal products in on-farm creameries for high-priced retail market segments. Yet, for many years the US has been the largest global import market for ewe milk cheeses, with annual imports of up to ~50% of the world's hard aged cheeses (FAO). China, with 12% of the annual global production, is currently the largest producer of ewe milk. Italy remains the largest exporter of hard aged cheeses (Balthazar et al., 2017). With 18% milk solids, the cheese yield from ewe milk is significantly higher than that from cow and goat milk, making ewe milk attractive milk for cheese production. However, seasonal availability of fresh ewe milk limits marketing opportunities and profitability of small-scale sheep farmers.

Opportunities to improve competitiveness are to increase the milk production of individual ewes to offset the challenge of seasonal production, to improve off-season conception rates and produce milk year-round, and to have a high lamb crop to tap into meat markets.

One option is to milk prolific traditional meat sheep breeds with high peak lactation yields. Enrolling meat breed ewes selected for accelerated lambing in a total dairy system utilizes their ability to breed out of season with high conception rates. A major consideration for the success of an intensely managed, dual purpose system is adequate nutrition throughout the production cycle. Fermentable dietary fiber is the focus of this nutritional research to use the abundance of idle forage acreage in the US Northeast and the advantage of grazing ewes during the gestational dry period. Successfully feeding ewes for an accelerated lambing, total dairy, multi-purpose system while maintaining optimal health and body condition for ewes is the main aim of this research.

MATERIAL AND METHODS

The hypotheses of this project were that the concentration of pfNDF in the diet would be positively correlated with feed intake and, thus, milk yield (Schotthofer et al., 2007) and that meat breed ewes managed in frequent and short lactations could achieve combined income from milk and lambs similar to that of long-lactation dairy breed ewes.

Between October 2016 and September 2018, 58 Finnsheep × Dorset crossbreed ewes were bred on the STAR accelerated lambing system and managed as a dairy flock. The ewes were divided into three management groups, with each group lambing three times during the experiment. Rebreeding was scheduled for day 73 of each lactation. Ewes within groups were milked in subsequent lactations year-round. This resulted in three 73-day lactation periods for each group with 219-day lambing intervals and nine 73-day lactations.

Table 1. Composition of experimental diets (% of DM). These diets were offered ad libitum with 350 to 500 g (varied with lactation) of hay per ewe per day.

Ingredient	30% pfNDF	35% pfNDF	40% pfNDF
Soy hulls	34.4	42.4	50.9
Wheat midds	20.1	20.1	20.1
Corn	31.5	24.1	16.2
Soybean meal	8.9	8.6	8.2
Molasses	1.7	1.7	1.7
Cornell sheep premix	1.06	1.06	1.06
Ammonium chloride	0.78	0.78	1.68
Calcium carbonate	1.34	1.12	0.89
Pellet binder	0.26	0.26	0.26
Estimated components			
DM (% of feed)	89.6	89.5	89.4
DDM	81.0	80.6	80.3
CP	17.0	17.0	17.1
NDF	36.1	41.1	46.5
pfNDF	30.5	35.1	40.1
INDF	5.6	6.0	6.4
NSCHO	38.9	34.0	28.7
EE	2.7	2.6	2.4
Ash	5.3	5.3	5.3

[1]Pelleted diets except for the first lactation of the first STAR group, which had no wheat midds, molasses, or pellet binder, but with 2.2% vegetable oil, more soy hulls, less calcium carbonate, more soybean meal, and 0.22% salt.

The experimental diets are presented in Table 1. Potentially fermentable fiber was defined by Thonney (2017) as the concentration of NDF in the diet minus the amount of indigestible NDF (INDF) at 1 X maintenance, with 1 X maintenance INDF being the concentration of indigestible dry matter at 1 X maintenance minus 10 to 15 percentage units of fecal DM as metabolic fecal losses (Van Soest, 1994). Soyhulls, an inexpensive by-product with a high proportion (~60%) of pfNDF, was the main source of fiber. Corn replaced soyhulls to achieve the desired pfNDF levels. The three levels of dietary pfNDF were formulated to be 30, 35, and 40% of the dietary dry matter. The diets were offered ad libitum with small amounts of hay to test their effect on intake and milk production.

At the beginning of the experiment, the ewes within each STAR group were randomly assigned to one of three pens. Three experimental diets rotated through these pens across the three lactations of each STAR group. Each pen was exposed to each experimental diet during the experiment.

Lambs were taken from each ewe within 12 hours of birth and reared artificially on cold milk. Beginning at DIM 1, milk yields for each ewe, and pen feed offered and refused were recorded twice daily. Weights were recorded weekly for each ewe and lamb. Milk, feed, and feed refusal samples were collected weekly. Ruminal fluid and ruminal fluid pH-values were collected twice during lactation 3 within each STAR group. Reproductive data were collected for each ewe.

The data were analyzed using the lmer procedure in R based upon the experimental design: a triply replicated (STAR group) Latin square with diet, pen within STAR group (rows), and lactation (columns) as fixed effects; ewe within pen as a random effect; and linear, quadratic, and cubic effects of days in milk (DIM) as possible continuous covariates to model lactation curves, with the possibility of different coefficients for each diet. Selected, preliminary results of the experiment are discussed below.

RESULTS AND DISCUSSION

The number of ewes per pen varied from 3 to 6 due to the breeding success prior to each lactation within STAR group. The data presented here include daily milk production for about 45 individual ewe lactations for each diet. As shown in Figure 1, ewes fed the 35% pfNDF diet produced the most milk ($P < 0.001$). Daily milk production averaged 1.3, 1.5, and 1.4 kg/day for ewes fed the 30, 35, and 40% pfNDF diets, respectively.

As portrayed in Figure 2, diet had a significant effect ($P < 0.001$) on DM intake. The DM intake of ewes fed the 35% diet correlates with higher milk production (Figure 1).

The small particle size of the pelleted diets did not have a negative effect on rumen health. Ruminal pH-values did not differ significantly among the diets (6.8, 7.0, and 6.8 for the 30, 35, and 40% pfNDF diets, respectively).

Feed efficiency was calculated by milk weight/DM intake (Figure 3). These values were not analyzed statistically but obtained by division; the modelled daily individual milk yield for each diet was divided by the modelled daily DM intake of each diet. Ewes fed the 35% pfNDF diet had higher feed efficiencies throughout lactation. Thus, ewes fed the 35% pfNDF diet were the most efficient and economical.

Rebreeding happened on day 73 of lactation. Weight loss in the beginning of lactation is not desirable. Ideally the ewes gain weight in early lactation up to breeding. This was achieved for each of the experimental diets. The weight gains showed an influence of diet, with the least weight gains for the ewes fed the diet containing 35% pfNDF. However, no significant difference due to diet was detected ($P = 0.884$).

There was no statistical influence of previous dietary level of pfNDF on conception rate (P = 0.273) or litter size (P = 0.856) in lactations 2 and 3. The ADG ranged between -0.189 g and 0.366 g for all ewes within all STAR groups and lactations did not show an effect on either conception rate (P = 0.812) or total number of lambs born (P = 0.361).

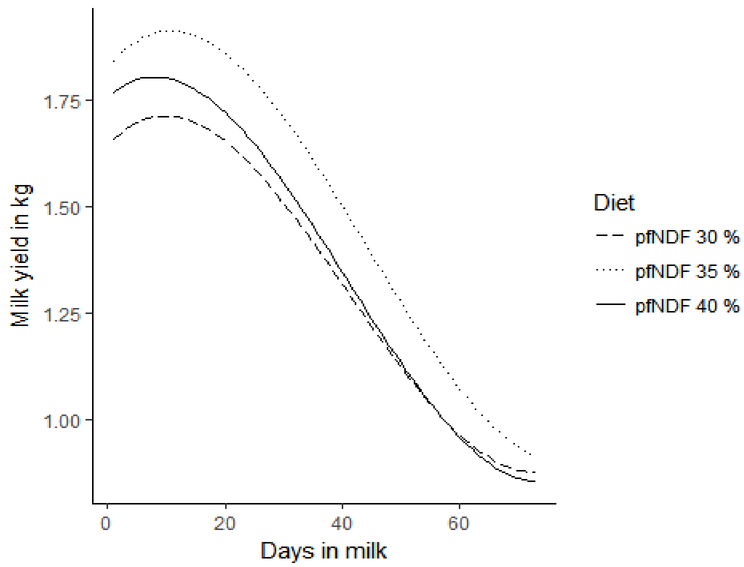

Figure 1. Lactation curves for ewes fed diets varying in concentrations of potentially-fermentable NDF.

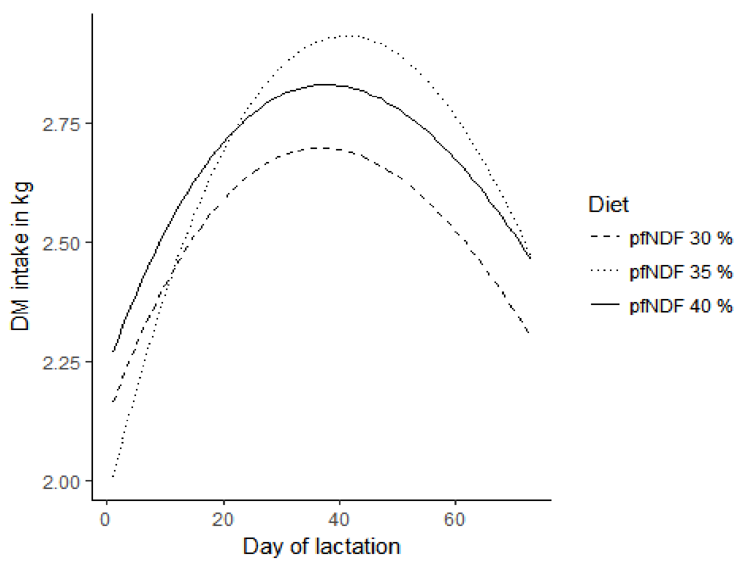

Figure 2. Daily dry matter intake.

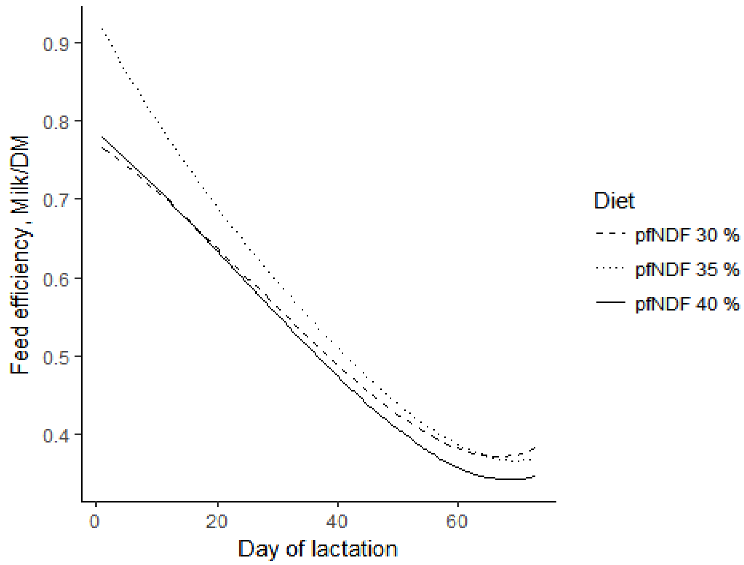

Figure 3. Feed efficiency.

The average weight of ewes increased from 68.7 kg in lactation 1 to 74.6 kg in lactation 3. Even though no statistical significance for lactation number was detected, the weight gains clearly had a positive impact on reproductive efficiency. Conception rates in the first reproductive cycle and the number of lambs born per lambing increased between lactations 1 and 3 (Table 2). No declines in fertility and fecundity, health, or body condition were detected in the 22-month experiment.

Table 2. Reproductive efficiency.

Item	Lactation 1	Lactation 2	Lactation 3
Conception rate, %	84	86	91
Conception in first cycle, %	85	79	93
Lambs born per lambing	2.3	2.2	2.7
Lambs raised per lambing	2.1	2.1	2.6
Lambs born per ewe per year	3.6	3.4	4.2
Lambs raised per ewe per year	3.3	3.3	4.1

Flushing strategies are advised to increase ewe weight and condition before and during breeding to increase the number of ovulated eggs and secure embryo survival, either with higher crude protein (Hoversland, 1958) or higher digestible carbohydrate (Habibizad et al., 2015) in the ration for various timespans prior and post introduction of the breeding ram. In this experiment, the ewes were fed relatively high protein and carbohydrate levels throughout lactation until breeding on day 73 of lactation. Six breeding groups (the second and third lactation of all groups) were taken off their concentrate ration immediately on day 73 of lactation to achieve dry-off. They were fed small amounts of low-quality hay (~ 9.3% protein, 72.1% aNDF, 50.3% ADF, 8.6% NFC) throughout the first two weeks of breeding to ensure optimal dry-off results. It seems the condition of the ewes during lactation prior to breeding had a higher impact on conception rate and fetal survival than digestible feed component level during breeding.

OUTLOOK

The achieved milk yields and lamb crop point toward success of accelerated dairy systems with Dorset and Finnsheep × Dorset meat ewes. The analysis of a variety of other measurements must be finalized for conclusive results. This includes blood NEFA, ruminal fluid VFA concentrations, and milk components.

Research has shown that East Friesian crossbred ewes can be manipulated to breed out of season in accelerated lambing systems (Peterson et al., 2005) and the advantage of lactational persistency of dairy breeds could be utilized by crossbreeding for a dairy setting. In a follow-up trial in Spring 2019, 30 yearling ewes from the Cornell flock with 25% East-Friesian dairy sheep genetics will be milked and rebred to study the impact of these genetics on lactation curve persistency, and ability to breed out of season in an accelerated system.

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